

L O C K H E E D M A R T I N



Memorandum

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To: M. Johnson /LM/S363

Via: E. Y. Azzi /LM/C70
J. L. Cox /LM/C70

From: G. K. Raviprakash /LM/C70

Subject: **Thermal Analysis of the Human Research Facility (HRF) Air Sampling Device**

SUMMARY

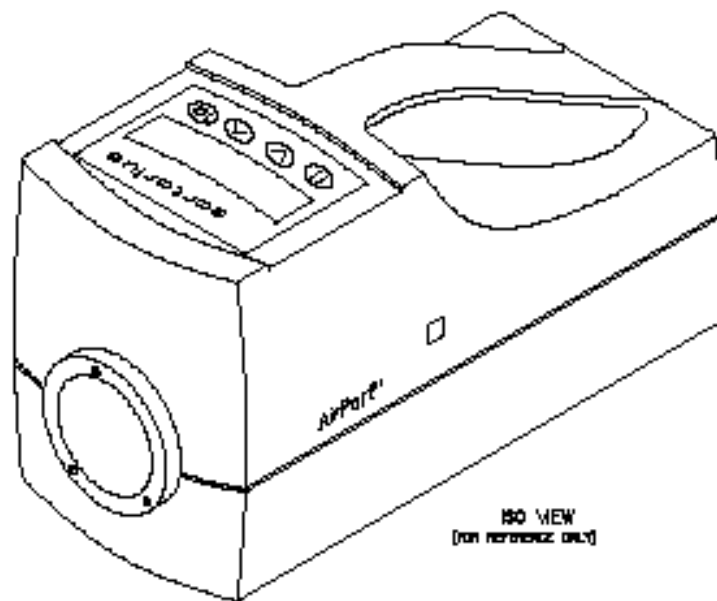
A thermal model was developed using SINDA to predict the component, enclosure and air temperatures of the HRF Air Sampling Device. The model was run, and the temperature histories were predicted. The steady state temperatures of the components were tabulated. The results indicate that the enclosure outside surface temperature is well below the touch temperature limit.

INTRODUCTION

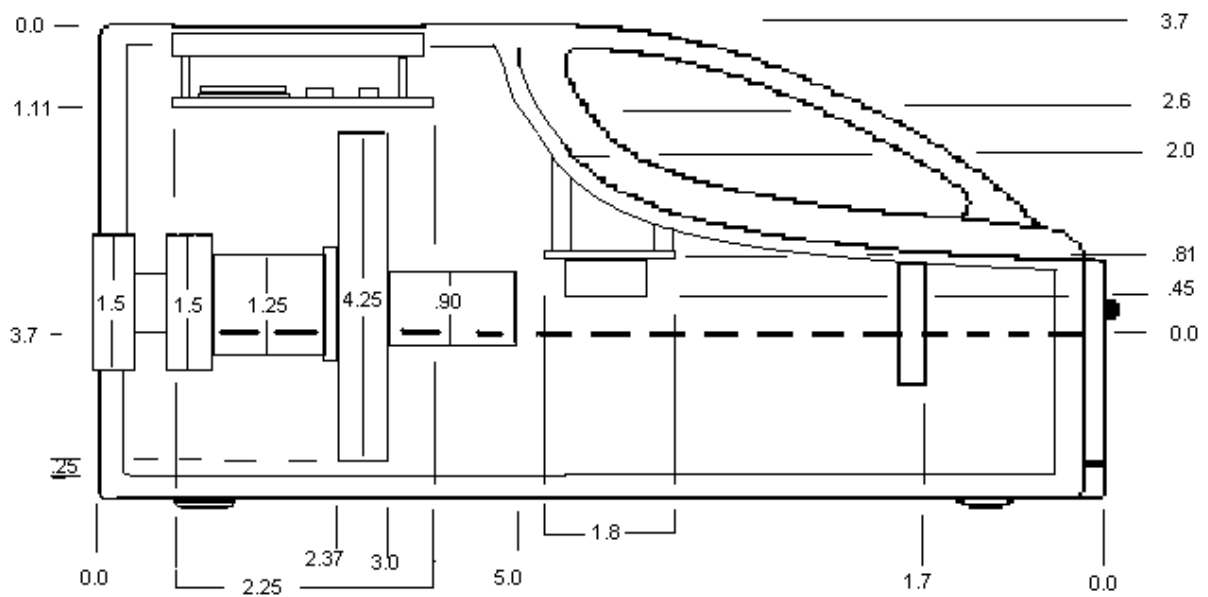
HRF Air Sampling Device is battery operated and will be used inside the International Space Station to sample air for the purpose of measuring the microbial organisms in the air. The HRF Air Sampling Device is shown in Figure 1. There is an air inlet (left side in Figure 1) for collection of air sample. The collected air is circulated inside the chamber. It cools the electronic components and motor, and exits through the vents (right side in Figure 1) into the cabin. The flow rate through the unit is 50 liters/minute. The major heat dissipating components are the motor and the PCBs located inside the unit. The heat load of components is shown in Table 1. The total heat load is 9.536 W.

Component	Heat Load in W
Control PCB	3.49
LCD PCB	0.246
Charger PCB	0.1
Motor	5.7
Total	9.536

Table 1. Heat Load of HRF Air Sampling Device



(a) Isometric View



(b) Schematic Showing Components

Figure 1. HRF Air Sampling Device

A SINDA model was developed to analyze the unit. The temperatures of the PCBs, motor and enclosure touch surfaces were predicted.

ASSUMPTIONS

1. The heat load is uniformly distributed on the Printed Circuit Boards.
2. The efficiency of the motor is 80%.
3. Emissivity of the outer surface of the motor is 0.4
4. Convection coefficient to the cabin is 1.14 W/m² K.
5. The inlet air temperature is 28 °C.

RESULTS

The model was run for five hours from the start of the unit. The results from the run are plotted in terms of temperature history. The temperature histories of PCBs and motor are shown in Figure 1. The steady state temperatures of the heat generating components are shown in Table 1.

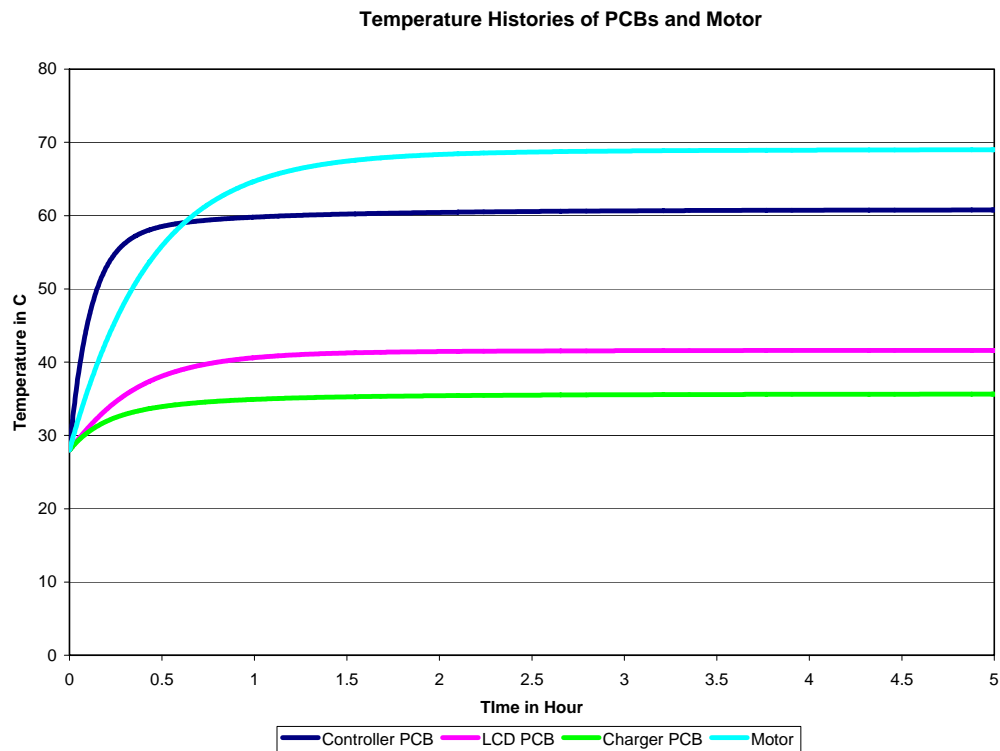


Figure 2. Temperature Histories of Heat Generating Components

Component	Temperature in C
Control PCB	60.8
LCD PCB	41.6
Charger PCB	35.6
Motor	69.0

Table 1 Steady State Temperatures of Heat Generating Components

The air temperature history plot is shown in Figure 3. The air inlet temperature is assumed to be 28 °C in the analysis. The steady state air exit temperature is 34.7 °C and is below the touch temperature limit.

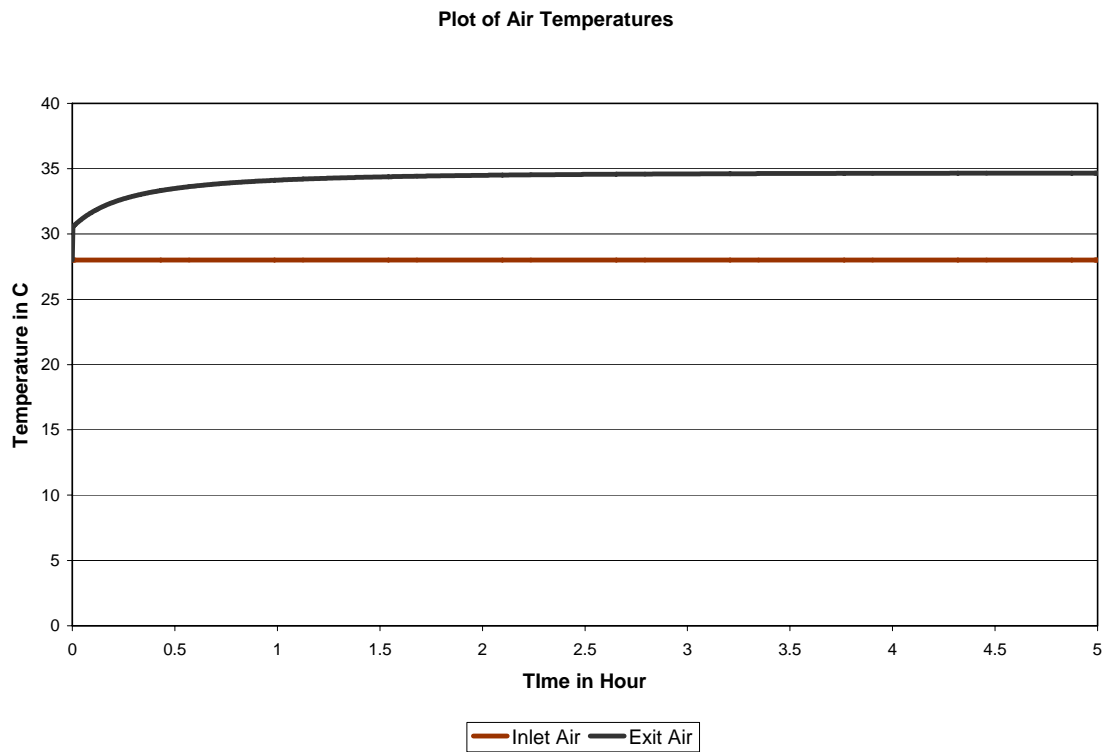


Figure 3. Air Temperatures History

The temperature history of the enclosure outer surface is shown in Figure 4. The enclosure outer temperatures are well below the touch temperature limit. The model was checked for heat balance as shown in Figure 5 by comparing the heat dissipated to the cabin and the heat generated inside the unit.

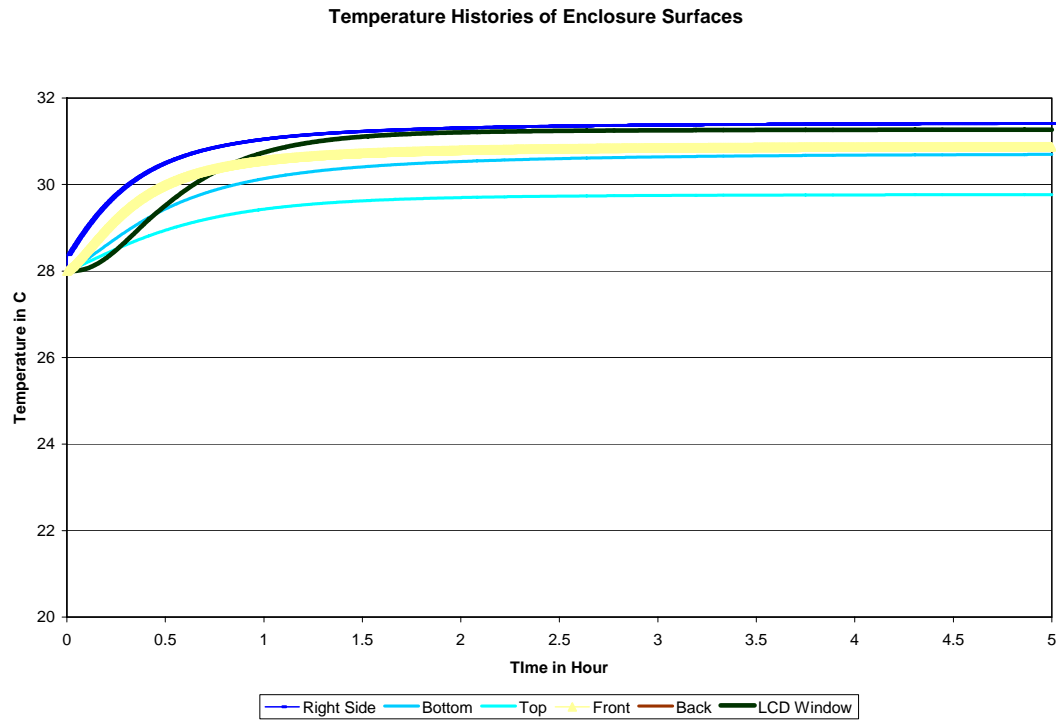


Figure 4. Enclosure Surface Temperature Plot

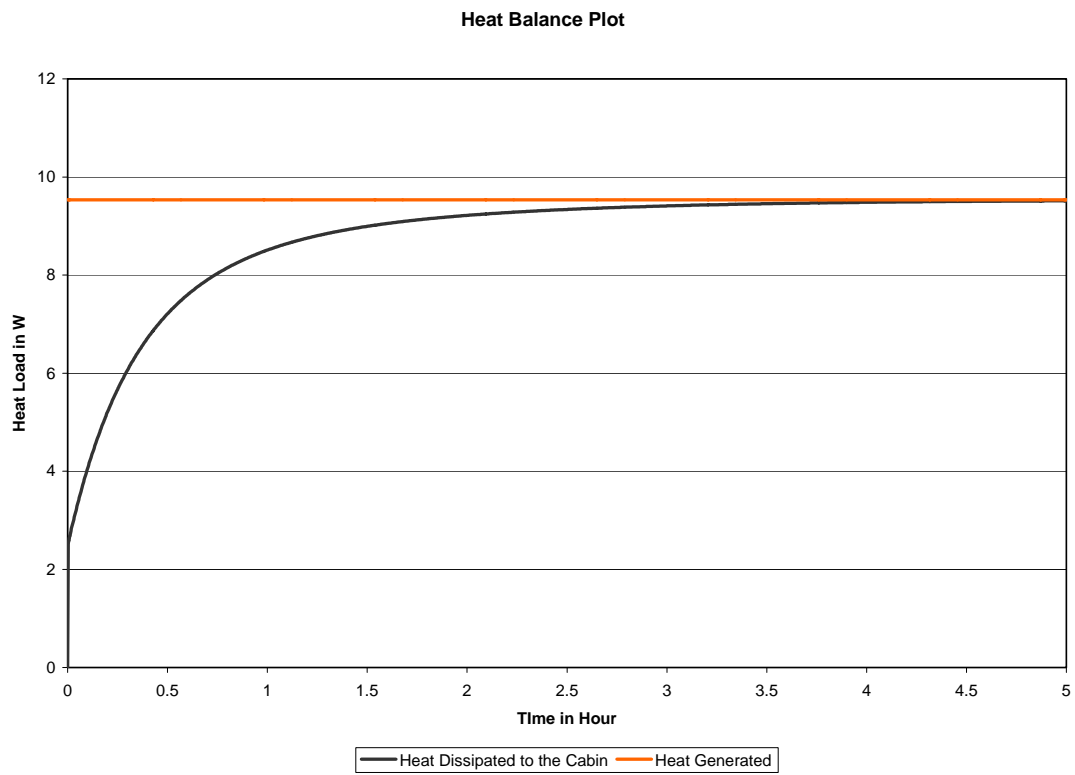


Figure 5. Heat Balance Plot

A run was made to compare the results with the data obtained from a test. The results from analysis and test compare well for the motor and exhaust air temperatures. The Controller PCB temperature predicted by analysis is higher than that from test. In the analysis, the flow distribution inside the unit was assumed. Detailed modeling for flow (CFD) and the components on the Controller board is required to perform more accurate prediction. However, the predicted Controller board temperature does not exceed component temperature limits.

CONCLUSIONS

A thermal model was developed using SINDA to analyze the HRF Air Sampling Device. The temperatures of the components, enclosure and exhaust air were predicted. The temperature histories were plotted. The results indicate that the enclosure outer surface temperatures are well below the touch temperature limit. The exit air temperature is below the touch temperature limit.

G. K. Raviprakash
Thermal Analysis Section